Microcavity Exciton-Polariton Qubits based on Long Lived Rabi Oscillators

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Abstract

Polaritonics is an interdisciplinary research area at the boundary of optics and solid state physics. It is aimed at the studies of light-matter interaction and dynamics of exciton-polaritons, or shortly polaritons: quasi-particles with bosonic statistics formed as a result of the light-exciton coupling. Nowadays polaritonics represents an indispensable tool for investigation of quantum coherent and nonlinear phenomena occurring at the matter-field interface in various area of condensed matter physics, quantum and atom optics.

Semiconductor microcavities serve as a solid-state laboratory to study dynamical and quantum effects in open and non-equilibrium systems of bosons. Particularly, one of the main achievements in the field of polaritonics is the creation of and manipulation with condensates characterized by a macroscopic occupation of a single quantum state and extended temporal and spatial coherences. In this sense, polaritonics presents a significant interest for quantum information science.

We propose a novel physical mechanism for creation of long lived macroscopic exciton-photon qubits in semiconductor microcavities with embedded quantum wells in the strong coupling regime, [1]. The polariton qubit is a superposition of lower branch (LP) and upper branch (UP) exciton-polariton states. We argue that the coherence time of Rabi oscillations can be dramatically enhanced due to their stimulated pumping from a permanent thermal reservoir of polaritons. We discuss applications of such qubits for quantum information processing, cloning and storage purposes.

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